D3 subE2

94. (Amended) A method of treating a semiconductor device, comprising:

providing a capacitor having a first plate, a dielectric on the first plate, a first conductive layer on the dielectric with the first conductive layer having an ability to associate with oxygen, an oxide layer on the first conductive layer, and a second conductive layer on the oxide layer;

exposing the capacitor to a thermal process; and

prior to exposure to the thermal process and prior to forming the second conductive layer on the first conductive layer, exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane to reduce an amount of oxygen associated with the first conductive material during formation of the second conductive layer and reduce a thickness of the oxide layer subsequently formed between the first and second conductive layers during exposure of the capacitor to the thermal process.

D4

102. (Amended) A method of treating a semiconductor device, comprising:

providing a first conductive plug, a first conductive layer on the plug, and a second conductive layer on the first conductive layer; and

prior to forming the second conductive layer, exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane to reduce the ability of the first conductive material to associate with oxygen.

REMARKS

Claims 91-98 and 102-105 are currently pending in the present patent application, with claims 1-3, 76-90, and 99-101 having been cancelled. In an Office Action mailed July 3, 2002, the Examiner rejected the pending claims under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,201,276 B1 to Agarwal *et al.* ("Agarwal").

Applicant's invention exposes a conductive layer to an oxygen-inhibiting material prior to the formation of the another layer or layers on the conductive layer to substantially

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reduce the association of oxygen with the conductive layer during formation of the other layer or layers. By reducing the amount of oxygen associated with the conductive layer, the electrical characteristics of a semiconductor device including the conductive layer are improved, as will be discussed in more detail below with reference to the disclosed embodiments of the invention. In order to help the Examiner appreciate certain distinctions between the pending claims and the subject matter of the applied reference, the disclosed embodiments of the invention will now be discussed in comparison to the applied reference. Specific distinctions between the pending claims and the applied references will be discussed after the discussion of the disclosed embodiments and the applied reference. This discussion of the differences between the disclosed embodiments and applied reference does not define the scope or interpretation of any of the claims.

One embodiment of the present invention is discussed with reference to Figures 7-10 in which an interposing layer 52 such as a tungsten nitride layer 52 is formed between a conductive plug 46 formed in a via 44 and a conductive line material 48 formed in a trench or container 50. The tungsten nitride layer 52 enhances the electrical contact between the line material and the plug, promotes adhesion of the line material within the container 50, prevents or slows the diffusion of materials across the tungsten nitride layer boundary, or serves some other purpose. As previously described, the tungsten nitride layer 52 may associate with oxygen after it is formed and subsequent thermal processes may result in the formation of an oxide layer 54 formed between the tungsten nitride layer 52 and the line material 48. Because the oxide layer 54 is an insulator, this layer will adversely affect the electrical connection between the line material 48 and the plug 46. By exposing the tungsten nitride layer 52 to an oxygen-inhibiting agent or a reducing atmosphere prior to formation of the line material 48, the thickness of the oxide layer 54 is reduced to a thickness of less than 10 angstroms or entirely eliminated as illustrated respectively in Figures 9 and 10. In this way, the conductive tungsten nitride layer 52 is exposed to an oxygen-inhibiting agent or reducing atmosphere prior to the line material 48 being formed on the conductive tungsten nitride layer to thereby reduce an ability of the conductive tungsten nitride layer to associate with oxygen. As described in the specification, the tungsten nitride layer 52 or other conductive layer may be treated in a plasma such as an N_2 and H_2 plasma, an NH_3 plasma, or an N_2 plasma. See page 6, lines 13-30 and page 7, lines 1-19.

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Furthermore, the conductive layer may be treated in a nitrogen-free gas, such as a plasma treatment including H_2, or may be treated with other materials such as diborane B_2H_6, phosphine PH_3, methylsilane CH_3SiH_3, hexamethyldisilane $(CH_3)_3Si\text{-}Si(CH_3)_3$, hexamethyldisilazane HMDS, carbon tetrafluoride CF_4, CHF_3, HCL, boron trichloride BCl_3, and silane SiH_4, and any combinations of these materials, as described on page 7, lines25-30, page 8, lines 1-16, and page 9, lines 1-12.

The Agarwal patent discloses a method for passivating a dielectric layer 16 to form a passivation layer 18a thereon as shown in Figures 1A and 1B. The passivation layer 18a can be formed by annealing the dielectric layer 16 in a reactive environment composed of various gaseous materials, such as nitrogen, hydrogen, ammonia, hydrazine, monomethyl hydrazine, H_2 and N_2, carbon tetrafluoride, CHF_3, HCL, boron trichloride, and mixtures thereof, as described in Column 4, lines 49-62. The exposure of the dielectric layer 16 to the reactive atmosphere forms the passivation layer 18a to limit or stop oxygen, carbon, or other species fro transporting between the dielectric layer and an upper electrode.

In another embodiment shown in Figures 2A and 2B of Agarwal, an electrically conductive lower electrode 14 is exposed to such a reactive environment to form a passivation layer 18b thereon and an insulating dielectric layer 16 is then formed on the passivation layer 18b. The passivation layers 18a, 18b may be electrically insulating layers, which is not a concern in Agarwal since a dielectric layer, which is another electrically insulating layer, is being formed on the passivation layer in either case. Thus, in Agarwal, when the conductive lower electrode 14 is passivated the nonconductive passivation layer 18b is formed on the lower electrode, which is fine since the dielectric layer 16 is then formed on the passivation layer. If another conductive layer was to be formed on the conductive lower electrode 14, however, the passivation layer 18b could inhibit electrical connection between the two conductive layers and form an unwanted capacitor corresponding to the electrode 14, layer 18b, and the other conductive layer. Thus, the passivation layer 18b may need to be removed to allow proper electrical connection between the electrode 14 and other conductive layer.

Moreover, even if the passivation layers 18a, 18b are conductive, no embodiment of Agarwal is directed to treating the conductive electrode 14 and then forming another conductive layer on the treated electrode. For example, in the embodiment depicted in Figure 5B

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of Agarwal, a lower electrode 14 is formed on a substrate 12 and a first dielectric layer 16a formed on the lower electrode. The first dielectric layer 16a is treated to form a passivation layer 18b thereon. While this passivation layer 18b may be conductive, and alternatively the dielectric layer 16a may all be converted to a conductive passivation layer, it is the dielectric layer that is being treated or passivated. A second dielectric layer 16b is then formed on the passivation layer 18b, and this second dielectric layer is then treated to form passivation layer 18a. An upper electrode 19 is then formed on the passivation layer 18a to complete construction of a capacitor. Although passivation layer 18a may be conductive and electrode 19 is conductive, this structure does not result from treating a first conductive layer to passivate the layer and then forming a second conductive layer directly on the passivated first conductive layer. This is true in all embodiments of Agarwal. None of the embodiments of Agarwal discloses passivating a first conductive layer and then forming a second conductive layer directly on such passivated first conductive layer.

Amended claim 91 recites a method of treating a semiconductor device. The method includes providing a capacitor having a first plate, a dielectric over the first plate, and a second plate over the dielectric, with the second plate including first and second conductive layers. The first conductive layer is exposed to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane to reduce an ability of the first conductive layer to associate with oxygen. The second conductive layer is formed on the first conductive layer, the second conductive layer being formed after the first conductive layer has been exposed to the material from the group.

Agarwal neither discloses nor suggests exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane to reduce an ability of the first conductive layer to associate with oxygen and forming a second conductive layer on this first conductive layer. Neither the embodiment of Figure 5B of Agarwal nor any other embodiment in Agarwal discloses exposing a first conductive layer to the recited materials and then forming another conductive layer on this layer. In the embodiment of Figure 5B it is the dielectric layers 16a, 16b that are being treated and not a conductive layer, and, moreover, the layers being treated are not being treated with materials in the group recited in amended claim 91. The combination of elements recited in claim 91 is thus allowable.

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Amended claim 94 recites a method of treating a semiconductor device. The method includes providing a capacitor having a first plate, a dielectric on the first plate, a first conductive layer on the dielectric with the first conductive layer having an ability to associate with oxygen, an oxide layer on the first conductive layer, and a second conductive layer on the oxide layer. The capacitor is exposed to a thermal process. Prior to exposure to the thermal process and prior to forming the second conductive layer on the first conductive layer, the method includes exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane to reduce an amount of oxygen associated with the first conductive material during formation of the second conductive layer and reduce a thickness of the oxide layer subsequently formed between the first and second conductive layers during exposure of the capacitor to the thermal process. Agarwal neither discloses nor suggests exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane to reduce an amount of oxygen associated with the first conductive material. Neither does Agarwal disclose forming a second conductive layer on this first conductive layer. Therefore, the combination of elements recited in amended claim 94 is allowable.

Amended claim 102 recites a method of treating a semiconductor device that includes providing a first conductive plug, a first conductive layer on the plug, and a second conductive layer on the first conductive layer. Prior to forming the second conductive layer, exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane to reduce the ability of the first conductive material to associate with oxygen. Once again, Agarwal neither discloses nor suggests exposing the first conductive layer to a material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane to reduce the ability of the first conductive material to associate with oxygen prior to forming the second conductive layer. The combination of elements recited in amended claim 102 is thus allowable.

The claims dependent on the independent claims are allowable for the same reasons as the independent claims, and because of the additional limitations added by the dependent claims. Note the amendments to dependent claim 92 do not narrow the scope of this

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claim but merely clarify the claimed subject matter by properly identifying the recited conductive layers.

The specification has been amended to include a patent number corresponding to an application number set forth in the specification. This amendment adds no new matter.

All pending claims are in condition for allowance, and favorable consideration and a Notice of Allowance are respectfully requested. The Examiner is requested to contact the undersigned at the number listed below for a telephone interview if, upon consideration of this amendment, the Examiner determines any pending claims are not in condition for allowance. The undersigned also requests the Examiner to direct all future correspondence to the address set forth below in the event the Examiner shows a different correspondence address for the attorney of record.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "**Version with Markings to Show Changes Made**".

Respectfully submitted,
DORSEY & WHITNEY LLP

Paul F. Rusyn

Paul F. Rusyn
Registration No. 42,118

PFR:asw
Enclosures:
Postcard
Check
Fee Transmittal Sheet (+ copy)

1420 Fifth Avenue, Suite 3400
Seattle, WA 98101-4010
(206) 903-8800 (telephone)
(206) 903-8820 (fax)

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

Paragraph beginning at line 4 of page 8 has been amended as follows:

Still other gases include diborane (B_2H_6); phosphine (PH_3); and carbon-silicon compounds such as methylsilane (CH_3SiH_3) and hexamethyldisilane $(CH_3)_3Si\text{-}Si(CH_3)_3$; and hexamethyldisilazane (HMDS). Additional alternate embodiments of the current invention use hydrazine (N_2H_4), monomethylhydrazine, carbon tetrafluoride (CF_4), CHF_3, HCl, and boron trichloride (BCl_3), which are also useful in passivating dielectrics, as addressed in copending application 09/114,847, now issued as U.S. Patent No. 6,201,276 B1. Also included are mixtures of any of the gases or types of gases described above. Exemplary non-plasma process parameters using these other gases include a flow rate of about 2 sccm to about 400 sccm for these gases; a flow rate of about 50 sccm to about 100 sccm for an inert carrier gas such as He or Ar; a temperature ranging from about 150 to about 600 degrees Celsius, a pressure ranging from about 50 millitorr to about 1 atmosphere (760 torr); and a process time ranging from about 50 to about 500 seconds. Again, one skilled in the art is aware that these parameters can be altered to achieve the same or a similar process.

In the Claims:

Claims 1-3, 76-90, and 99-101 have been cancelled.

Claims 91, 92, 94, and 102 have been amended as follows:

91. (Amended) A method of treating a semiconductor device, comprising:

providing a capacitor having a first plate, a dielectric over the first plate, and a second plate over the dielectric, the second plate including first and second conductive layers;

exposing said first conductive layer to a [selection] material selected from the group consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane[, HCL, boron trichloride, and combinations thereof] to reduce an ability of the first conductive layer to associate with oxygen; and

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forming the second conductive layer on the first conductive layer, the second conductive layer being formed after the first conductive layer has been exposed to the material from the group [selection consisting of diborane, phosphine, methylsilane, hexamethyldisilane, hexamethyldisilazane, HCL, boron trichloride, and combinations thereof].

92. (Amended) The method of claim 91, wherein providing a capacitor comprises providing an in-process capacitor; and the method further comprises providing a [second] third conductive layer over the [first] second conductive layer.

94. (Amended) A method of treating a semiconductor device, comprising:

providing a capacitor having a first plate, a dielectric on the first plate, a first conductive layer on the dielectric with the first conductive layer having an ability to associate with oxygen, an oxide layer on the first conductive layer, and a second conductive layer on the oxide layer;

exposing the capacitor to a thermal process; and

prior to exposure to the thermal process and prior to forming the second conductive layer on the first conductive layer, exposing the first conductive layer to a material selected from the group [selection] consisting of diborane, phosphine, methylsilane, hexamethyldisilane, and hexamethyldisilazane[, HCL, boron trichloride, and combinations thereof] to reduce an amount of oxygen associated with the first conductive material during formation of the second conductive layer and reduce a thickness of the oxide layer subsequently formed between the first and second conductive layers during exposure of the capacitor to the thermal process.

102. (Amended) A method of treating a semiconductor device, comprising:

providing a first conductive plug, a first conductive layer on the plug, and a second conductive layer on the first conductive layer; and

prior to forming the second conductive layer, exposing the first conductive layer to a material selected from the group [selection] consisting of diborane, phosphine,

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methylsilane, hexamethyldisilane, <u>and</u> hexamethyldisilazane[, HCL, boron trichloride, and combinations thereof] to reduce the ability of the first conductive material to associate with oxygen.

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